

A 50 W CW transmitter for 137 kHz

Drew Diamond VK3XU

At the time of writing, there is a real possibility of our gaining access in the near future to an LF band near 2200 metres, 135.7 to 137.8 kHz. Offered here are plans for a small CW transmitter for that band, based largely on previous models for 1.8 MHz and 507 kHz.

Output power is adjustable between 0 and nominally 50 W into 50 ohms. Harmonics are measured at greater than 50 dB below fundamental. Frequency range is from 135 to about 141 kHz. The robust class-E power amplifier can withstand extreme load mis-match (including accidental short or open-circuit load) for reasonable periods without damage.

Circuit

So that the VFO may run continuously, and thus dodge any warm-up drift between "overs", the oscillator operates at 32 times the output frequency, 4.32 to about 4.5 MHz. Therefore, the VFO signal cannot be heard on the operating frequency during receive periods. This frequency was chosen simply because it employs reasonably dimensioned oscillator tank components for a physically small, yet very stable, VFO assembly.

Output from the 2N5484 VFO buffer (Fig 1) is applied to the clock input pin 10 of a 74HC4040 modulo-2 divider chip, where the divide by 32 output appears at pin 3. The diode clamp at pin 10 moves the 6 V p-p sine signal (from the buffer) fully into the positive region, thus driving the '4040 without need of a Schmitt trigger. The divider must wait for a low at the (R)eset input, pin 11, in order to output a 137 kHz square-wave at pin 3.

An NE555 timer chip performs the transmit timing function. On key closure, the low presented to the (T)rig input, pin 2 of the '555 causes a high to output at pin 3, which is applied to the base of a 2N2222 (to invert the high to low required to enable the divider) at pin 11 of the '4040.

Key activity is also applied to the base of a 2N3638 keying transistor. When base current flows via key closure to ground, +6 V is supplied to the PA bias pot (which also functions as power

output control) and the 74HC04 driver chip, 5 gates of which are paralleled to supply sufficient drive to the gate of the PA MOSFET. A 220 nF capacitor between base and collector of the '3638 provides a nicely shaped ramp of about 3 ms rise and 10 ms fall for clean, click-free keying.

Directly keying (sending) stops, and between words and some characters, the '555 timer will "time-out", and allow reception (on a separate antenna - see "Operation" below).

The class-E PA and low-pass filter (Reference 6) are evolved from those used in previous models for 1.8 MHz and 507 kHz. Efficiency for the prototype is about 75%, where 65 V dc @ 1 A produces 50 W RF output (the lesser efficiency than the 1.8 MHz model is attributed to the higher copper losses in the rather large 'fly-back' coil (yes, I did try Litz wire, among other things - same result). The curious are pointed to References 1 to 4 for a description of class-E operation.

Do also explore Lloyd Butler's (VK5BR) excellent Web site (Reference

5) for further contemporary practical information on building LF transmitters, receivers, and lots more.

Construction

The homemade aluminium chassis/cabinet pictured in Photo 1 measures 70 x 265 x 230 mm HWD. The bottom chassis panel functions as a heat-sink for the BUZ90A PA MOSFET (very little waste heat is generated).

The power supply, VFO, and driver/PA are each accommodated upon "paddyboard" (Reference 7) circuit boards. Suggested layouts are shown in Fig 2. However, any preferred construction style will serve, provided that signal carrying component leads (eg coupling and by-pass capacitors, etc) are reasonably short, and the general plan pictured in Photo 2 is followed.

A rectangular hole of 12 x 18 mm should be provided in the RF board so that the BUZ90A may be attached to the bottom panel - include a silicone washer and the usual hardware. A solder tag is mounted under the 3 mm hex fixing nut for the drain connection.



Photo 1: The 137 kHz Class-E 50 W CW transmitter.



The NE 555 timer chip may be installed in an 8-pin socket that is in turn soldered upon a suitably sized substrate,

As a simple means of adjusting the fly-back circuit, the series coil is comprised of two mutually-coupled 60 μH solenoids wound upon loop-stick material. By altering the spacing between these, their combined inductance is variable from about 130 μH to 220 μH , thus allowing the fly-back circuit to be “fine-tuned” for best efficiency.

The coils each comprise 31 turns of 1

The variable capacitor may be any well-made part with a range about 3 - 25 pF (see Parts below). Ordinary "ugly" construction is quite suited to oscillator work and, provided that lead

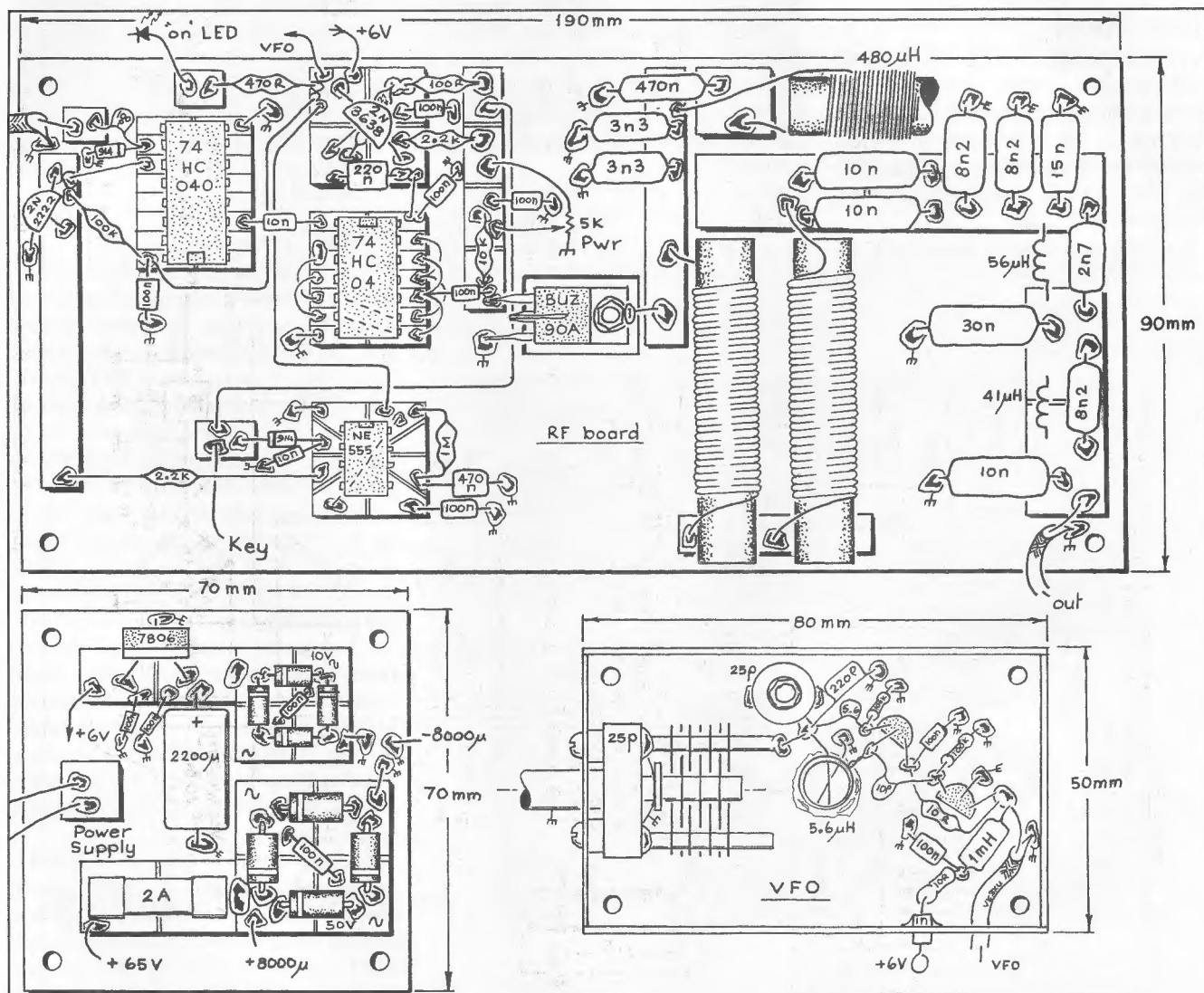


Figure 2: Layout of the components on the “paddyboards” and in the VFO enclosure.

lengths are short and components are mounted rigidly, your oscillator should be remarkably stable.

The VFO coil is 50 turns of 0.5 mm (#24 B&S) ecw wound firmly upon a 40 mm length of common 7.9 mm diameter "Kilometrico" pen barrel. This material is easy to work and has been found, in numerous examples, to provide good mechanical stability and low loss for oscillator coil applications. Drill a 1 mm hole in two places across the former's diameter, as shown in Fig 1. The source tap (a twisted "pig-tail") is at 8 turns from the "earthy" end. The coil may be fixed to the VFO board with a blob of hot-melt glue.

All wiring on the 240 V ac mains side of the transformer MUST be suitably covered to prevent accidental contact. Include a 4 A "slow-blow" fuse in the line side.

Operation

Carefully inspect your wiring and soldering for quality, accuracy, and absence of solder "bridges" (between Vero tracks). Double check for correct polarity of all polarised devices, e.g. ICs, electrolytics, diodes, regulators, transistors, FETs, etc.

It would be shrewd to first verify the supply rails. Remove the 2 A PA fuse

from the power supply board. Apply mains power and check that you have (about) +65 (70 V dc no-load) and +6 V dc where indicated.

If an oscilloscope is available, close the key and observe (with a x10 probe) the signal at the gate of the BUZ90A. You should see a ~137 kHz square-wave of about 6 V p-p. Some salient signal waveforms are shown on the circuit to aid in any necessary trouble-shooting. With the VFO cover in place, adjust the 25 pF trimmer so that 135 kHz is generated with the variable cap at full mesh, and about 141 kHz at minimum mesh.

Replace the 2 A fuse. Connect a suitably rated 50 ohm dummy load/power meter to the output. (Confirm that your power meter will work down to 137 kHz. The current meter part of the recently outlined twin-meter SWR/current meter reads about 20 % low so, at 50 W, you should read about 0.8 A. The SWR meter, being a relative indicator, reads normally). Set the 5 k "Pwr" potentiometer to about half travel. Close the key, whereupon drain current (ID) should rise, and some power output should be indicated.

Hook the 'scope x10 probe to the drain of the BUZ90A. Turn the Pwr potentiometer fully clockwise. You should see a pulse waveform with a p-p

amplitude of about 250 V. Adjust the fly-back coil inductance by moving the coils together (better efficiency) or further apart (more power) until the smaller "pip" on the right side of the main pulse is reduced to a flat-line. The voltages are not dangerous but, as you can receive an RF "bite" from the fly-back components, take care. Drain current should be about 1 A at 50 W output.

Now hook your x10 oscilloscope probe to the output connector. With the 'scope time-base at (say) 1 μ s/division, observe a clean sine-wave output signal.

Verify CW keying. Set the 'scope for ~10 ms/div and observe a nicely ramped keyed wave-shape, free of blips or spikes (you may notice a smidgen of 100 Hz ripple which is quite acceptable).

In the opinion of this writer, it is not recommended that the main transmitting antenna be used on receive. Rather, better results will probably be obtained where a receiving loop is employed (Reference 8). It is hoped to address this application in a future article.

You will find much of interest concerning LF/MF antennas and propagation on VK3ACA's Web site (Reference 9).

Parts

All the ordinary components are available from our usual electronics suppliers, including Altronics, Electronic World and Jaycar. The mains transformer should have a secondary of 50 Vac (two series 25 Vac windings) @ 3.2 A, such as a Jaycar MT 2114 or Altronics M 5325. The 74HC4040 is known to be available from Electronic World (03 9726 3860).

Capacitors marked "10 n" and "100 n" are 50 V monolithic types, except for that across the 50 V rectifier bridge, which should be a 100 n/200 V polypropylene. For good frequency stability, the 220 pF VFO capacitor marked "s.m." (silver mica) should be a >100V silver mica type. For best efficiency, all capacitors in the fly-back and low pass filter should be "s.m." (if you have them) or low-loss "Orange Drop" capacitors. These may be ordered from Antique Electronic Supply (www.tubesandmore.com).

A single length of Neosid 37-256-31 ferrite rod (Altronics L-2540), when divided into three equal pieces, supplies enough material for the job. To cut the rod to length, grind a shallow groove around the circumference, then grip the rod with thumbs each side of the groove,

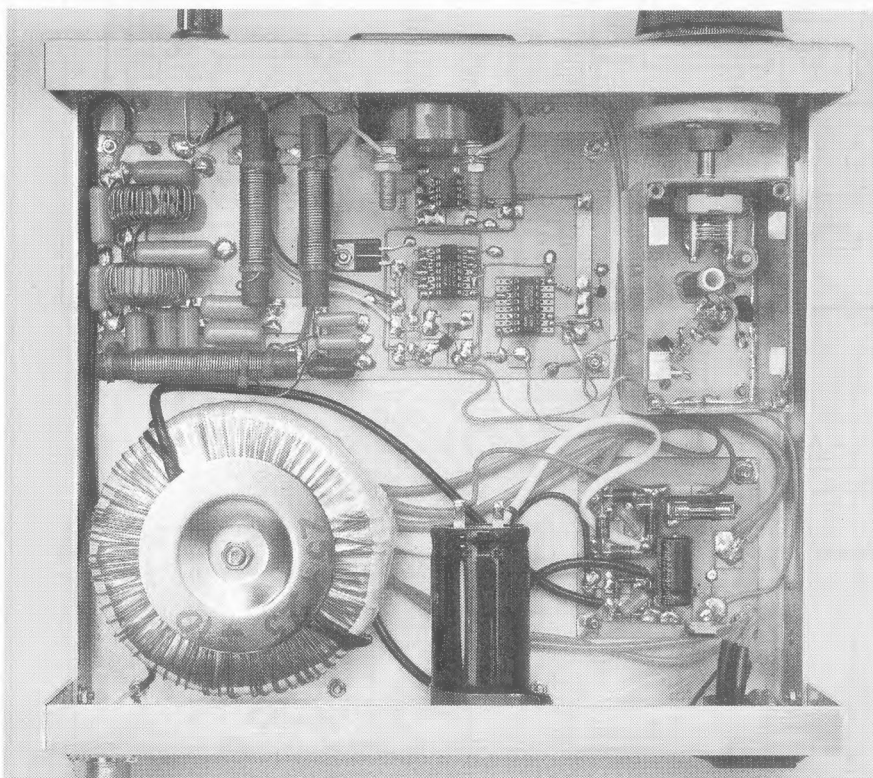


Photo 2: View inside the transmitter with the cover and VFO lid removed.

and snap it, as you would break a stick.

Siemens BUZ90A MOSFETs (P/N 12329) may be purchased from Rockby Electronics (<http://www.rockby.com.au>). Rockby also stock some values of silver mica capacitors.

Amidon T106-2 toroids may be ordered from any of the suppliers regularly listed in the Hamads of *Amateur Radio*.

The 3 - 25 pF variable capacitor for

the VFO must be first-class. An English Jackson Bros or "Polar" would be ideal. The trim capacitor should be an air dielectric type, such as a 25 or 30 pF Philips "beehive" (I am not in the parts business, but do please contact me by 'phone [03 9722 1620] or letter if you cannot locate a suitable variable capacitor, or are held up on one or two other items).

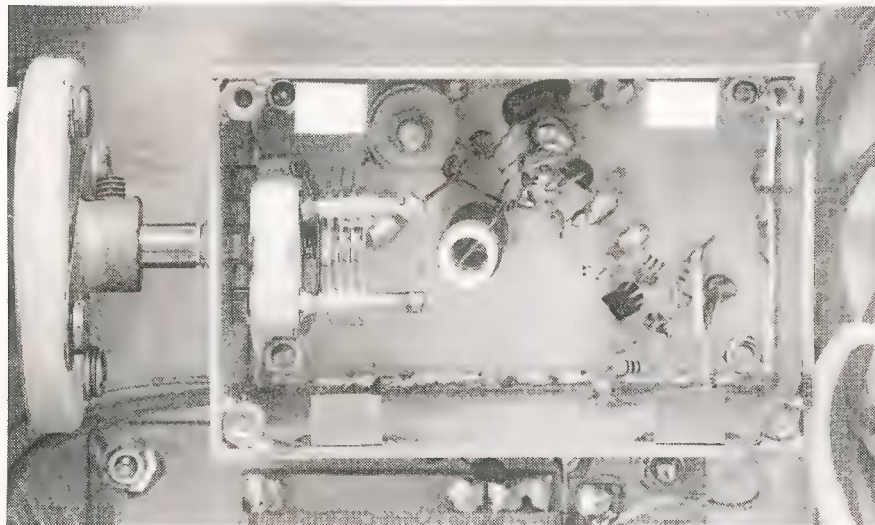


Photo 3: The VFO assembly.

References and Further Reading

1. "An AM/CW Transmitter for 1.8 MHz with Class-E PA"; *Amateur Radio*, June 2007.
2. "Class-E RF Power Amplifiers"; N Sokal, WA1HQC, QEX, Jan/Feb 2001.
3. *Experimental Methods in RF Design*; W Hayward et al; ARRL, pp 2.31, 2.32.
4. "High Efficiency Class-E Power Amplifiers"; D Rutledge et al; QST, May-June 1997.
5. <http://users.tpg.com.au/ldbutler/>
6. "Low-pass filters for solid-state linear amplifiers"; K Shubert, WA0JYK, *Ham Radio*, March 1974.
7. "Paddyboard" Circuit Construction - Revised"; *Amateur Radio*, May 2005.
8. *Radio Communication Handbook*; RSGB, LF chapter in recent editions.
9. <http://member.melbpc.org.au/~jadcock/>

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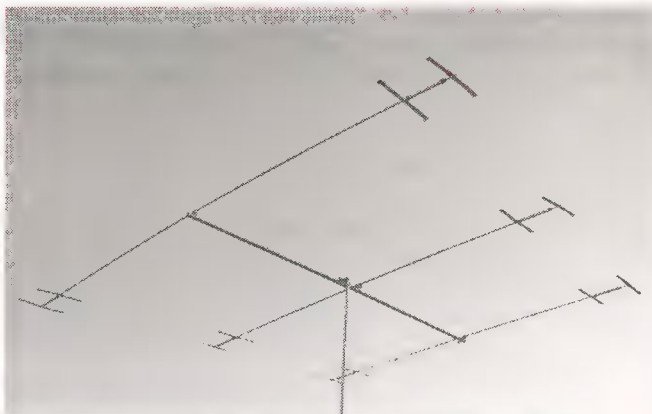
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